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Millennia of magmatism recorded in crustal xenoliths from Southwest Greenland

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Eruption of CO_2-rich ultramafic magma involves rapid ascent of mantle-derived magmas loaded with mantle xenoliths and xenocrysts (>30 vol%). The dynamics and duration of such eruptions are increasingly well constrained; the causes are nevertheless largely unclear. To address this issue, we performed a petrological and speedometric analysis of well-preserved crustal xenoliths from aillikite dikes at Sisimiut and Sarfartôq alkaline provinces, W Greenland.

The xenoliths represent mafic granulites, scavenged from c. 25-36 km depth within the mid-to-lower crust. The rocks are infiltrated by various types of melt in grain boundaries, cracks and veins. Zirconium-in rutile thermometry and Fe-in-rutile speedometry indicate melt temperature of c. 1,015 °C and melt exposure time of a few hours for the host aillikite, implying an average ascent rate of c. 2 m/s. This is slower than average ascent rates of mantle cargo (4-40 m/s [1]), suggesting a slowing-down of transport at shallow levels.

Local diffusive zoning in garnet indicates up to several millenia of melt-assisted mass transport. This demonstrates a two-stage magmatic process of rapid melt ascent preceded by a previously unrecognized long magmatic episode. Melt infiltration at Sismiut lasted 10 times longer than at Sarfartôq, and unlike at Sarfartôq was initially associated with carbonate- and sulfide-rich melt. This contrast reflects a fundamental difference in the devolatilization efficiency of parental carbonatite magma. The rapid development of the Sarfartôq system is ascribed to the local lithospheric mantle being highly depleted [2] and rich in the decarbonation reactant orthopyroxene [3]. A link is also proposed between this feature, and the occurrence of REE-carbonatite and diamond-bearing mantle cargo at that particular location.

References

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